

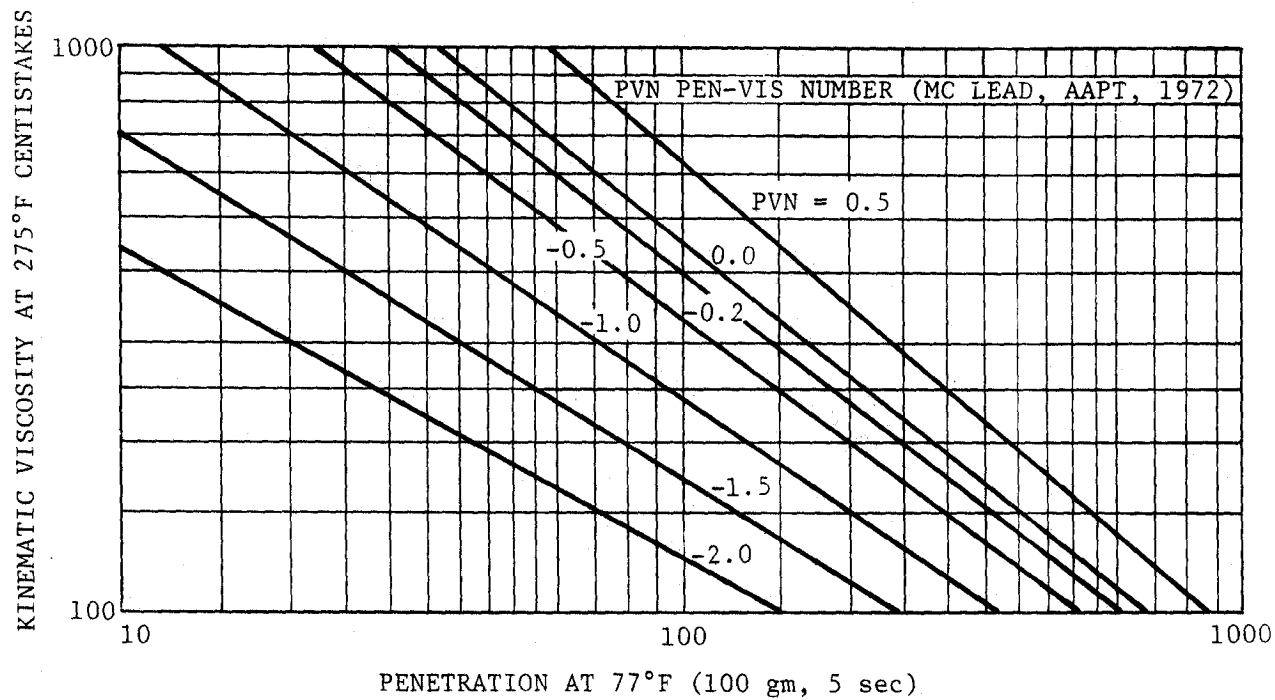
APPENDIX D

MINIMIZING LOW-TEMPERATURE CONTRACTION CRACKING
OF BITUMINOUS PAVEMENTS

D-1. Causes and effects of low-temperature contraction cracks. In cold regions, one of the most prevalent and objectionable modes of distress, affecting only bituminous pavements, is thermal cracking. This type of cracking includes thermal fatigue cracking caused by repeated (often diurnal) cycles of high and moderately low temperatures, and low-temperature contraction cracking, which results from thermal contraction of the bituminous-stabilized layer. The thermal contraction induces tensile stresses in the cold and relatively brittle bituminous mixture in the layer because it is partially restrained by friction along the interface with the supporting layer. In very cold regions, some of the cracks may penetrate through the pavement and down into the underlying materials. Unfortunately, in the winter, when the most severe tensile stresses develop, flexible pavements are less ductile and more brittle than in other seasons. Closely spaced thermal cracks are particularly detrimental in airfield pavements because the crack edges may ravel and produce surface debris that can damage jet engines. The ingress of water through the cracks also tends to cause loss of bond, increasing the rate of stripping, and resulting in some cases in a depression at the crack brought about by raveling of the lip of the crack and pumping of the fine fraction of base material. During the winter months when the entire pavement and substructure is frozen and raised slightly above its normal summer level, deicing solution can enter these cracks and cause localized thawing of the base and a pavement depression adjacent to the crack. In other cases, water entering these cracks can form an ice lens below the crack that produces an upward lipping of the crack edges. Both of these effects result in rough-riding qualities and often secondary cracks are produced that parallel the major crack. Pavement roughness at low-temperature contraction cracks can be especially severe where subgrade soils are expansive clays; moisture entering the cracks causes localized swelling of subgrade soil, which results in upheaval of the pavement surface at and adjacent to each crack.

D-2. Effect of penetration and viscosity of asphalt. Currently, the most effective means available to minimize low-temperature contraction cracking is the use of asphalt that becomes less brittle at low temperatures. This may be accomplished in part by use of soft grades of asphalt such as AC-5 and AC-2.5. It may also be accomplished in part by use of asphalt of low temperature-susceptibility. A useful measure of temperature-susceptibility of asphalt cement is the pen-vis number (PVN) which may be determined from the penetration at 77 degrees F. and the kinematic viscosity at 275 degrees F. (fig D-1). Current Corps of Engineers specifications for asphalt for use in pavements in cold regions require a PVN not lower than -0.5. For airfields and major roadways in severely cold climates, asphalt cement is to be

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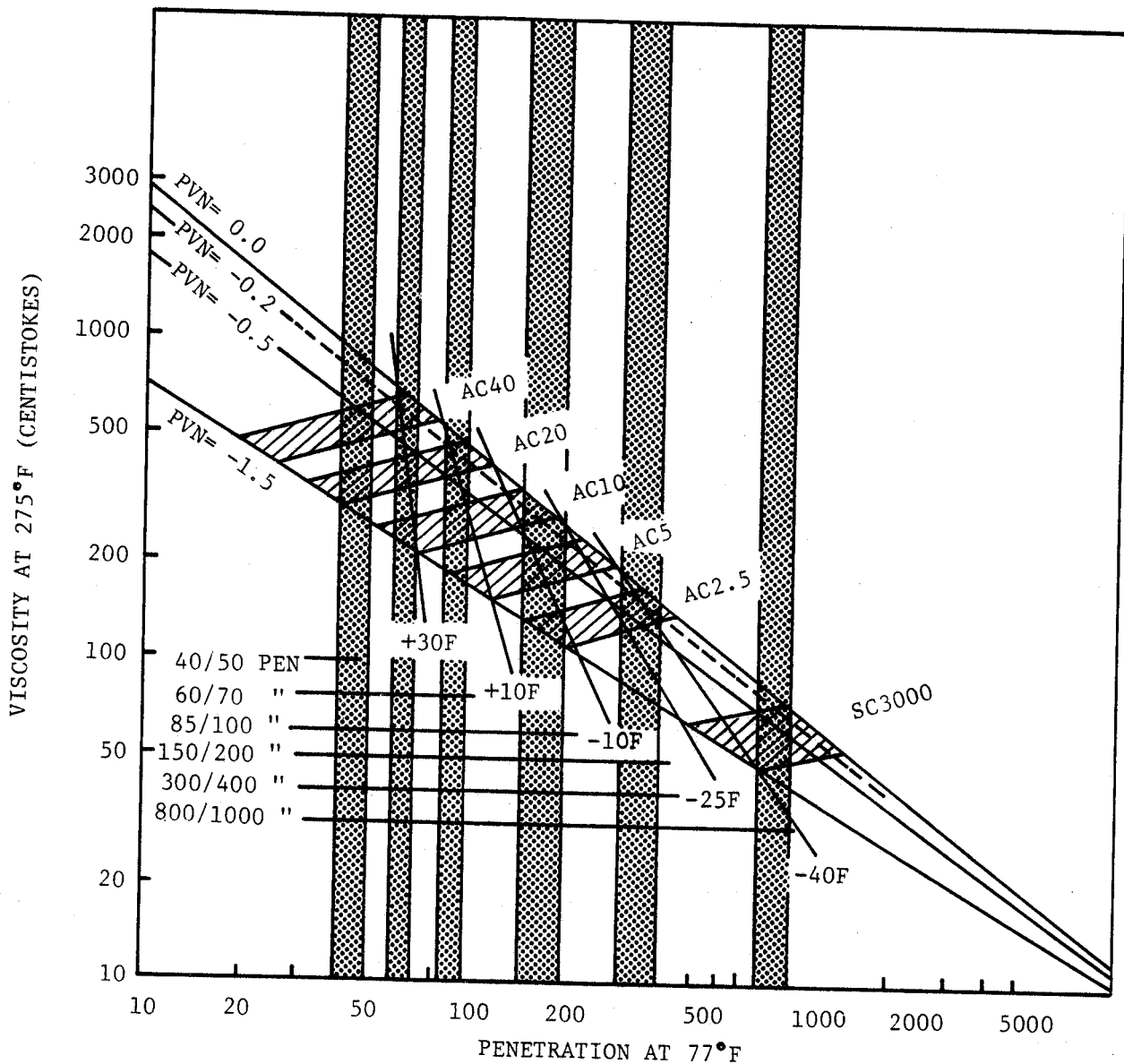
FIGURE D-1. PEN-VIS NUMBERS OF ASPHALT CEMENT

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selected and specified in accordance with the requirements for special grades having a minimum PVN of -0.2.

D-3. Selection of asphalt. Figure D-2 is a useful guide for selection of asphalts that will resist low-temperature cracking for various minimum temperatures. To minimize low-temperature contraction cracking during a pavement's service life, a grade of asphalt should be selected that lies to the right of the diagonal line representing the lowest temperature expected during the service life at a depth of 2 inches below the pavement surface. In the absence of temperature data from nearby pavements, the minimum temperature at 2 inches below the surface may be taken as the lowest air temperature in the period of record (not less than 10 years), plus 5 degrees F. It can be seen from figure D-2 that if asphalt of relatively high PVN can be obtained, selection of extremely soft grades of asphalt will be unnecessary, except in the most severely cold environments. Asphalt of grades AC-2.5, -5, or -10, or the equivalent AR grades, should be selected for airfield pavements and roads in cold regions. For roads with a design index of 4 or less in extremely cold regions, slow-curing road oil SC-3000 also is acceptable.

D-4. Effect of mix design variables. It may not always be possible to use the extremely soft grades indicated by figure D-2 for very low temperatures and still produce mixtures meeting the requirements of EM 1110-3-131 and EM 1110-3-141. In that event, the softest grade that will still meet those requirements should always be selected. In designing asphalt-aggregate mixtures in accordance with EM 1110-3-131 and EM 1110-3-141, it should be realized that age-hardening of asphalt, which leads to increasing incidence of low-temperature cracking, will be retarded if air voids are maintained near the lower specified limit. Consequently, mix design and compaction requirements are especially critical for pavements that will experience low temperatures. Asphalt content in most cases should be set at a level above the optimum value, and it may be necessary to readjust the aggregate gradation slightly to accommodate the additional asphalt.



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FIGURE D-2. GUIDE TO SELECTION OF ASPHALT FOR PAVEMENTS IN COLD REGIONS